low capacity channels **8855** through which the intended destination for the respective data units can be reached.

The SONET network can perform at least one of SONET switching, SONET multiplexing, and SONET de-multiplexing. In a possible embodiment, SONET switching is implemented by using at least one of time driven switching (TDS) technology and time driven priority technology, as described above in this disclosure.

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications that fall within the scope of the claims.

WHAT IS CLAIMED IS:

1. A communications system, for controlling the transport of SONET channels comprising a contiguous plurality of SONET frames each having a predefined time duration, the system comprising:

a Common Time Reference (CTR), divided into a plurality of contiguous time frames (TFs), wherein the time frames have a plurality of predefined time durations;

means for separating each of the SONET channels into at least one SONET sub-channel each comprising of a sequence of contiguous SONET frames;

wherein each SONET frame consists of at least one data unit;

first means for mapping each of the SONET frames to selected ones of the time frames; and

means for providing for data transport of the SONET frames responsive to the first means for mapping and the CTR.

2. The system as in Claim 1, wherein each of the SONET frames is comprised of a plurality of parts;

wherein the first means for mapping selectively maps each of the parts of one of the SONET frames to each of multiple respective ones of the time frames.

3. The system as in Claim 2, wherein each of the parts is at least one of the following: STS-1, STS-3, STS-12, STS-48, STS-192, and STS-768;

4. The system as in Claim 2, wherein the first means for mapping selectively maps at least one of the following: multiple ones of the SONET frames, and multiple ones of the parts of the SONET frames to a respective one of the time frames.

5. The system as in Claim 4, wherein the means for providing the data transport is a time-driven switching apparatus; the system further comprising:

a switching node with a plurality of input ports each having a unique address and a plurality of output ports each having a unique address;

a position logic for determining a relative position for each of said respective incoming parts of the SONET frame within the respective particular time frame; and

a forwarding and transmit delineation controller responsive to (1) the unique address of the input port associated with each one of the incoming parts of the SONET frames; (2) the associated time frame of arrival; and (3) the associated relative position for each said respective incoming parts of the SONET frame within said time frame of arrival, to provide a routing to an associated particular one of the output ports at an associated particular position and within an associated second particular time frame.

6. The system as in claim 5, wherein the forwarding and transmit delineation controller provides routing of each of the incoming parts of the SONET frames to a plurality of the output ports, each of the plurality of the incoming parts of the SONET frames having a respective unique associated particular position within an associated one of the predefined time frames.

7. The system as in claim 5, wherein each of the time frames has a defined duration from start to end, wherein each of the input ports is comprised of a serial receiver that provides position delimiters associated with each of the incoming parts of the SONET frames coupled thereto, wherein the position logic is a position counter, wherein said position counter counts the position delimiters that have occurred since the start of the respective one of the time frames.

8. The system as in claim 7, wherein the time frames are cyclically recurring, wherein a sequence of position delimiters within the cyclically recurring time frames is implicitly defined by a predefined sequence of time units of equal duration.

9. The system as in claim 7, wherein the time frames are cyclically recurring, wherein the sequence of position delimiters within the cyclically recurring time frames is defined by a predefined sequence of time intervals of arbitrarily different duration.

10. The system as in claim 7, wherein at least one of the start of the time frame and the end of the time frame is marked by a time frame delimiter.

11. The system as in claim 7, wherein the position logic is incremented at predefined time intervals relative to the start of the time frame.

12. The system as in claim 11, wherein each of the positions is of predefined time duration.

13. The system as in Claim 4, wherein the means for providing the data transport is a time-driven priority apparatus; said system further comprising:

a pipe comprising at least two switching nodes interconnected via at least one optical channel in a path; a Forwarding and Transmit Delineation Controller for assigning selected predefined time frames for transfer into and out from each of the respective switching nodes responsive to the common time reference;

wherein for each switching node within the pipe there is a first predefined time frame within which a respective one of the parts of the SONET frame is transferred into the respective switching node, and a second predefined time frame within which the respective part of the SONET frame is forwarded out of the respective switching node; and

wherein the time frame assignment provides consistent fixed intervals between the time between the input to and output from the pipe.

14. The system as in claim 13, wherein there are a plurality of the pipes, each of the pipes comprising at least two of the switching nodes interconnected via optical channels in a path.

15. The system as in claim 14, wherein the optical channel is a connection between two adjacent ones of the switching nodes; and wherein each of the optical channels can be used simultaneously by at least two of the pipes.

16. The system as in claim 14, wherein for each of the same predefined time frames, multiple SONET frames can be transferred utilizing at least two of the pipes.

17. The system as in Claim 4, wherein the means for providing the data transport is a fractional lambda pipe apparatus; said system further comprising:

a first communications switch and a second communications switch connected by at least one communications link, comprising at least one channel, for transmitting a plurality of data units from said communications link to the output of the switching system;

wherein predefined number of time frames (TFs) are grouped into a time cycle (TC);

wherein predefined number of time cycles (TCs) are grouped into a super cycle (CS);

wherein each of the communications switches is further comprised of a plurality of input ports and a plurality of output ports, each of the input ports connected to and receiving data units from the communications link from at least one of the channels, and each of the output ports connected and transmitting data units to the communications link over at least one of the channels;

wherein each of the communications links is connected between one of the output ports on the first communications switch and one of the input ports on the second communications switch;

wherein each of the communications switches has a switch controller, coupled to the CTR, the respective input ports, and the respective output ports;

wherein each of the communications switches has a switch fabric coupled to the respective switch controller, the respective input ports, and the respective output ports;

wherein each of the switch controllers is responsive to the CTR for scheduling connection to the switch fabric from a respective one of the input ports, on a respective one of the input channels during a respective one of the time frames;

wherein each of the switch controllers defines the coupling from each one of the respective input ports for data units received during any one of the time frames, on a respective one of the channels, for output during a predefined time frame to at least one selected one of the respective output ports on at least one selected respective one of the channels; and

wherein the data units that are output during a first predefined time frame on a selected respective one of the channels from the respective output port on the first communications switch are forwarded from the respective output port of the second communications switch during a second predefined time frame on a selected respective one of the channels responsive to the CTR.

18. The system as in claim 17,

wherein the plurality of input ports each receives data units over at least one of a plurality of incoming channels (*j*), and wherein the plurality of output ports each sends data units over at least one of a plurality of outgoing channels (*l*);

wherein each of the incoming channels (*j*) has a unique time reference (UTR-j) that is independent of the CTR; and

wherein the (UTR-j) is divided into super cycles, time cycles, and time frames of the same durations as the super cycles, time cycles, and time frames of the CTR.

19. The system as in claim 18, further comprising:

a plurality of buffer queues, wherein each of the respective buffer queues is associated, for each of the time frames, with a combination of one of the incoming channels and one of the outgoing channels; and

a mapping controller within the switch controller for logically mapping, for each of the (UTR-j) time frames, selected incoming channels (j) to selected buffer queues, and for logically mapping, for each of the CTR time frames, selected ones of the plurality of buffer queues to selected outgoing channels (*l*);

wherein each of the buffer queues is further comprised of an alignment subsystem comprised of a plurality of time frame queues, wherein each of the time frame queues comprises means to determine that the respective time frame queue is empty, wherein each of the time frame queues further comprises means to determine that the respective time frame queue is not empty;

wherein the data units that arrive via the incoming channel (*j*) are stored in the respective time frame queue of the alignment subsystem responsive to the mapping controller; and

wherein the mapping controller further provides for coupling of selected ones of the time frame queues to respective ones of the outgoing channels (*l*), for transfer of the respective stored data units during the respective associated CTR time frames.

20. The system as in claim 19,

wherein the alignment subsystem, responsive to the mapping controller, transfers all of the data units associated with a respective first time frame as defined by the UTR-j into an empty first time frame queue from incoming channel (*j*), during the respective first time frame as defined by UTR-j, wherein the respective time frame queue is designated as full;

wherein the alignment subsystem, responsive to the mapping controller, transfers data units out of a full second time frame queue to outgoing channel (*l*), during a selected one of the time frames (TFs) as defined by the CTR, wherein the second time frame queue is designated as empty; and

wherein the first time frame queue and the second time frame queue are mutually exclusive at all times.

21. The switch as in claim 20, wherein the time frame queues are comprised of at least two, three, and more than three time frame queues.

22. The system as in Claim 1, further comprising:

second means for mapping the data transport within at least part of one time frame to respective ones of the SONET frames associated with at least one SONET sub-channel;

means for multiplexing the respective ones of the SONET frames associated with at least one SONET sub-channel, to form a sequence of SONET frames associated with a second SONET channel.

23. The system as in Claim 17, wherein the switch fabric is at least one of: an optical cross-bar, an optical banyan network, a Lithium-Niobate optical switch, an Indium Phosphate optical switch, a 2-D MEMS optical switch, a 3-D MEMS optical switch, a semiconductor optical amplifier (SOA) based optical switch, an holographic optical switch, and Bubble optical switch.

24. A communications system for controlling the transport of SONET channels comprising SONET frames, the system comprising:

a Common Time Reference (CTR) divided into a plurality of contiguous predefined time frames;

wherein the SONET frames are transported as data units during selected ones of the predefined time frames;

the system further comprising:

means for mapping the data units from the respective predefined time frames to the respective SONET frames associated with at least one SONET sub-channel; and

means for multiplexing the respective SONET frames associated with the at least one SONET sub-channel to form a sequence of SONET frames associated with a respective one of the SONET channels.

25. The system as in Claim 24, wherein the means for mapping maps the data units from multiple ones of the time frames to respective ones of the SONET frames.

26. The system as in Claim 24, wherein each of the time frames consists of at least one sub-time frame;

wherein the means for mapping maps data units from each of the sub-time frames to a selected one of the SONET frames.

27. The system as in Claim 26, wherein data units are combined from a plurality of sub-time frames for transmission as respective SONET frames responsive to the means for multiplexing.

28. The system as in Claim 24, wherein the data unit transport is provided at a first bit rate, and wherein each of the SONET channels has a second bit rate;

wherein the first bit rate is larger that the second bit rate.

29. The system as in Claim 28, wherein the first bit rate is an integer multiple of the second bit rate.

30. The system as in Claim 28, wherein each of the SONET channels has an independent second bit rate;

wherein the first bit rate is at least the sum of the independent second bit rates.

31. The system as in Claim 30, wherein the second bit rate is at least one of OC-3, OC-12, OC-48, OC-192, and OC-768.

32. The system as in Claim 1, wherein the means for providing for data transport provides for multiple independent data transports, each having a respective first bit rate;

wherein each of the SONET channels has a respective second bit rate;

wherein the sum of the respective first bit rates is at least equal to the sum of the second bit rates.

33. The system as in Claim 32, wherein the second bit rate is at least one of OC-3, OC-12, OC-48, OC-192, and OC-768.

34. The system as in Claim 1, wherein the SONET frame is comprised of portions comprising a transport overhead (TOH), a path overhead (POH) and payload (Payload).

35. The system as in Claim 34, wherein the means for data transport provides for transfer of only the POH and Payload portions of the SONET frame.

36. The system as in Claim 34, wherein the means for data transport provides for transfer of only the Payload portion of the SONET frame.

37. A communications method, for controlling the transport of SONET channels comprising a contiguous plurality of SONET frames each having a predefined time duration, wherein each SONET frame consists of at least one data unit, the method comprising:

providing a Common Time Reference (CTR);

dividing the CTR into a plurality of contiguous time frames (TFs), wherein the time frames have a plurality of predefined time durations;

separating each of the SONET channels into at least one SONET sub-channel each comprised of a sequence of contiguous SONET frames;

mapping each of the SONET frames to selected ones of the time frames; and

providing for data transport of the SONET frames responsive to the mapping and the CTR.

38. The method as in Claim 37, wherein each of the SONET frames is comprised of a plurality of parts, the method further comprising:

selectively mapping each of the parts of one of the SONET frames to each of multiple respective ones of the time frames.

39. The method as in Claim 38, further comprising:

selectively mapping to a respective one of the time frames at least one of the following: STS-1, STS-3, STS-12, STS-48, STS-192, and STS-768.

40. The method as in Claim 38, further comprising:

selectively mapping to a respective one of the time frames at least one of the following: multiple ones of the SONET frames, and multiple ones of the parts of the SONET frames.

41. The method as in Claim 40, further comprising:

providing a switching node with a plurality of input ports each having a unique address and a plurality of output ports each having a unique address;

determining a relative position for each of said respective incoming parts of the SONET frame within the respective particular time frame; and

providing a routing to an associated particular one of the output ports at an associated particular position and within an associated second particular time frame responsive to the unique address of the input port associated with each one of the incoming parts of the SONET frames; and the associated relative position for each said respective incoming parts of the SONET frame within said time frame of arrival.

42. The method as in claim 41, further comprising:

routing of each of the incoming parts of the SONET frames to a plurality of the output ports, each of the plurality of the incoming parts of the SONET frames having a respective unique associated particular position within an associated one of the predefined time frames.

43. The method as in Claim 41, further comprising:

providing a pipe comprising at least two of the switching nodes interconnected via at least one optical channel in a path;

assigning selected predefined time frames for transfer into and out from each of the respective switching nodes responsive to the common time reference;

transferring respective parts of the SONET frame into the respective switching node for each switching node within the pipe during a first predefined time frame;

forwarding the respective parts of the SONET frame out of the respective switching node during a second predefined time frame; and

providing consistent fixed intervals between the time between the input to and output from the pipe responsive to the time frame assignment.

44. The method as in claim 43, further comprising:

providing a plurality of the pipes, each of the pipes comprising at least two of the switching nodes interconnected via optical channels in a path.

45. The method as in claim 44, further comprising:

connecting the optical channel between two adjacent ones of the switching nodes; and

utilizing at least one of the communications links simultaneously for at least two of the pipes.